VERSION WITH MARKINGS TO SHOW CHANGES MADE

BACKGROUND OF THE INVENTION

There are various ways of sensing the rotation of an induction motor. Tachogenerators, resolvers and Hall-effect sensors are some of the conventional sensing devices. But all such sensing methods necessitate ~~entail~~ the use of additional hardware on the induction-motor frame itself. In many applications, where there are physical or cost constraints, it may not be possible to use additional sensing devices on the motor frame. ~~In existing machines, due to physical constraints, it is, many a time, not possible to do hardware modifications on the mechanical design.~~ When an induction motor is being driven by using a variable-speed ~~AC~~ drive, it is possible to define or estimate ~~estimate, define or know~~ the angular movement of the rotor. But when the power to the drive is turned off, and the induction motor keeps rotating either due to its rotor's moment of inertia or due to some external mechanical force, it is not possible to sense the angular movement of the rotor of the induction motor without the use of an extra device coupled with the frame of the induction motor.

In many applications, it becomes essential to be able to detect ~~sense~~ the angular movement of the rotor of the induction motor after electrical power driving the motor has been switched off. ~~off.~~ Like in the case of the high-rpm induction motor driving high-speed grinding wheels resting on oil-fed hydrostatic bearings. ~~At the times of sudden power failure, if the grinding wheels are in rotation, it is essential to continue oil supply to the hydrostatic bearing.~~ As there are physical constraints to ~~in~~ introducing an additional conventional sensor in the above-mentioned example, a solution is needed to sense the angular movement of the driving induction motor's rotor. ~~the present invention was successfully introduced, which utilized the driving induction motor itself as a sensor for the rotor's angular movement.~~ There are low-cost areas of application, like electrical saws and industrial blowers, where the easy sensing of rotation of the driving induction motor after electrical power to the motor is withdrawn can provide a safety interlock without any -- ~~the advantage would be that no~~ alteration in the ~~has to be done in the electro-~~ mechanical construction of such equipment.

BRIEF SUMMARY OF THE INVENTION

The rotor of a common ~~any~~ induction motor is in the form of multiple shorted secondary windings of a transformer. The electrical conductor is made either of aluminum ~~Aluminium~~ or copper; ~~Copper~~; the magnetic circuit comprises of silicon-steel ~~Silicon-Steel~~ stampings stacked together. When power is switched off to an induction motor, the residual magnetism of the silicon-steel ~~Silicon-Steel~~ stampings form multiple poles on the angular face of the rotor. These multiple magnetic poles induce minute electrical current in the stator winding ~~windings~~ just like as it happens in a small alternator. The frequency of the output voltage generated in this manner is directly proportional to the angular velocity ~~movement~~ of the rotor of the induction motor. Contactors and relays are arranged in a manner so that this sensor voltage could be directed to an amplifier and/or counter to be able to draw inference from the sensor signal.

~~Nearly four years back the object of the invention was to give a starting command to a three-phase battery-driven inverter to keep running the oil-pump motor till the time the grinding wheels of a Toyoda* Cam Grinding Machine came to a stop. These grinding wheels rested on a precision hydrostatic bearing to which the oil pump constantly keeps pumping oil. In a hydrostatic bearing, maintaining a required oil pressure in the bearing is a must, and the absence of which even for a brief while damages the expensive bearing, making it unserviceable.~~

~~During the last four years the invention has been implemented on several similar machines to obtain the same objectives as described above.~~ The absence of any external device on the induction motor makes this invention particularly easy to implement. Many a time it is physically impossible to accommodate any piece of hardware in and around an induction motor, in these circumstances the present invention could be of particular use. In addition, in applications where ~~even when~~ the motor is not powered, ~~but~~ and is rotating due to some other mechanical linkages, this invention could be used to detect

~~quantify~~ that movement without putting ~~using~~ any conventional additional device on the motor ~~like tachogenerator, resolver or encoder~~ – thus saving both cost and space.

This invention successfully solves the problem of detecting during a power outage the rotation of the totor of the spindle-driving induction motor in a grinding machine with hydrostatic bearings supporting the spindle, which holds big grinding wheels. The impossibility of fitting a sensor in the extremely harsh conditions near the grinding wheels means having a sensor on the spindle-driving induction motor, which is physically very difficult. Any alteration in the mechanical mounting of the spindle-driving induction motor could disturb the mechanical alignment, which is absolutely necessary for a satisfactory operation of the grinding machine. This invention obviates the need to even touch the mechanical parts of the grinding machine and solves the problem by using the spindle-driving induction motor as a sensor to detect its own rotation during a power outage to be able to give command to a battery-powered inverter to commence electrical supply to the oil-pump motor supplying oil to the very expensive and critical hydrostatic bearings supporting the spindle.

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DETAILED DESCRIPTION OF THE INVENTION

In most of the general-purpose induction motors, the rotor is of squirrel-cage construction, ~~arrangement~~, where the shorted secondary windings of the induction motor are placed. The primary winding generally is on the stator. The magnetic circuit of the induction motor consists of silicon-steel ~~Silicon-Steel~~ stampings stacked together to reduce eddy-current losses in the magnetic circuit. After an induction motor is switched off from the mains supply, theoretically, the residual magnetism of the ferro-magnetic ~~magnetic~~ circuit tends to be zero. Still, little bit of residual magnetism remains in the rotor as well as the stator. Weak but distinct permanent magnets ~~magnets,~~ formed on the rotor, make the induction motor rotating without electrical driving power ~~power,~~ function as an alternator producing weak but distinct electrical waves. Till now, this miniscule signal either used to get sunk in the mains power lines, or ~~and~~ went unused, in the absence of a scheme to utilize it. ~~unobserved.~~ The voltage ~~Voltage~~ and the frequency of this tachogenerator signal is proportional to the rpm of the induction motor running due to its moment of inertia in the absence of any external electrical driving power. ~~motive force.~~ Gradually the rotor of the induction motor comes to a halt. With this ~~This is when~~ the signal coming out of the stator winding stops. Generally, the rms value of this signal voltage is between 30 and 0.1 Volts for practical sensing applications to be successfully implemented. At voltage ~~Voltage~~ levels below 0.1 Volt, the noise voltages ~~Voltages~~ interfere, and discrimination of the signal deteriorates. In the case of a three-phase induction motor, mostly, there is ~~Most of the three-phase induction motor supply lines have~~ a contactor in series with the mains supply to turn the induction motor on and off. Even when the induction motor is being driven by a variable-speed drive, usually there is a three-pole ~~three pole~~ contactor in conjunction with an over-current relay ~~Over-Current Relay~~ to turn off the induction motor in case of emergencies. This contactor (CN 1 in FIG. 1) in series with the mains supply to the three inputs U, V and W (~~U, V, W in~~ FIG. 1) disconnects the motor from the mains supply as soon as the mains power is disconnected

or turns ~~is turned~~ off. At this instant, ~~instance,~~ two connections ~~connexions~~ to any two of the three inputs U, V and W (FIG.1) going through two independent, normally closed ~~normally-closed~~ contacts of a relay or a contactor reach the tachogenerator signal from the induction motor acting as a residual-magnet alternator to an amplifier and/or counter. This two-pole, double-throw contactor or relay (CN 2) is of much lower current rating than the main motor-control contactor CN 1 in FIG.1. CN 2 and CN 1 could be driven by any logical signal or directly by the mains supply.

Due to high moment of inertia, in certain ~~many~~ cases, induction motors connected to a flywheel ~~freewheeling~~ load ~~loads~~ like a high-speed grinding-wheel stack ~~assemblies~~ keeps ~~keep~~ rotating ~~revolving~~ for nearly 10 minutes before stopping fully. In this case, the self-generated tachogenerator signal from the induction motor would be available throughout those 10 minutes after a mains power failure. ~~In the case of this self-generated tacho signal being amplified after a mains power failure,~~ The ~~the~~ amplifier and/or counter for this tachogenerator signal would need ~~needs to have~~ a power ~~source~~ source in the form of a rechargeable battery or a high-value capacitor. ~~This could be incorporated in the amplifier section in the form of appropriate rechargeable battery or a high-value super-capacitor~~

In some applications -- as was the case or providing starting trigger voltage ~~Voltage~~ to a battery-powered, three-phase inverter ~~UPS~~ -- the self-generated tachogenerator signal can be directly applied after simple full-wave rectification utilizing a bridge rectifier. In such applications, ~~the UPS or~~ the battery-driven inverter or the UPS runs for a preset time after receiving a start signal from the self-generated tachogenerator output of the induction motor whose angular movement was to be detected. ~~known~~

In the application of this invention, ~~invention~~ it is important that three-core or twin-core ~~twin-core~~ shielded cable is ~~cables are~~ used to wire CN 1 to ~~and~~ the motor M (in Fig. 1). Number of cores in the shielded cable depends ~~depend~~ upon whether the motor in question is a single-phase or three-phase one. ~~single phase or three phase.~~ The external shield of the cable has to be grounded, preferably, on both the ends.

When an amplifier and/or counter is used to process the self-generated tachogenerator signal from the application motor, it is important to have an over-voltage ~~overvoltage~~ protection circuit at the front end of the amplifier and/or counter module

This ~~this~~ would prevent the amplifier from getting damaged if the relay contacts of CN 2 (FIG.1) got ~~get~~ stuck; in that case full ~~motor~~ supply voltage ~~Voltage~~ would ~~will~~ appear on ~~at~~ the input of the amplifier ~~Amplifier~~ and/or counter.

The ~~Most of the~~ windings of most of the induction motors are of fairly low impedance. ~~impedence.~~ This improves the signal-to-noise ~~signal to noise~~ ratio of the self-generated tachoganerator signal coming out of the motor stator windings. Furthermore, induction motor housings are electrically and magnetically fully shielded; which prevents external sources of noise from breaking in. The robustness of construction, low source impedance ~~impedence~~ and ease of use make this self-generated tachogenerator output from any induction motor a more suitable solution in some mains hold-up or power-off applications compared to the use of an additional sensor with the induction motor to detect ~~know~~ the angular movement of the rotor of the motor.

In another addition to the application, CN 2 in FIG.1 could be of 3-pole type. The three-phase self-generated ~~selfgenerated~~ tachogenerator output is sent to a phase-discriminating ~~an~~ amplifier ~~discriminator~~ to detect the phase relationship between the three signal phases. This will logically indicate the direction of rotation of the rotor of the induction motor.

In comparatively smaller-capacity induction motors, the use of CN2 could be avoided by using CN 1 contactor with auxiliary ~~auxilliary~~ normally closed ~~normally-closed~~ contacts. In large contactors, auxiliary ~~auxilliary~~ contacts would gradually get deposited with residues left out of the repeated arcing taking place during the make-and-break operation of main contacts. ~~tend to catch deposits emanated out of the main motor contacts' make and break.~~

CLAIM ~~CLAIMS~~

What I claim as my invention is: ~~(Claim Number 1) Discovering the property of any induction motor to act as an alternator, when rotating without the driving electrical power, providing low-power alternating-current output, the frequency and voltage of which is proportional to the angular speed of the rotor of the induction motor, and the alternation of phases of the three-phase alternating-current output is in sympathy with the direction of rotation of the magnetic field which is in logical relation to the rotation of the rotor.~~

~~(Dependent Claim Number 1) To utilize the low-power alternating-current output from the induction motor being generated in conditions described in Claim Number 1, the use of one or two multi-pole electromagnetic switches to make a changeover so that the low-power alternating-current output being generated by the mechanical rotation of the rotor does not sink into the extremely-low impedence mains power-supply side, and is routed as a signal to some process-control module or equipment with or without a display.~~

1. An arrangement for using a single-phase or three-phase induction motor as a sensor to sense mechanical rotation of said induction motor's rotor by utilizing low-power alternating current generated in the stator winding or windings of said induction motor by mechanical rotation of the rotor of said induction motor at the time of said induction motor's driving electrical power completely diconnected from said induction motor, for the purposes of process control and/or display of said rotor's mechanical rotation, comprising:

said single-phase or three-phase induction motor;

two sets of electromagnetically operated switches; wherein first set of electromagnetically operated switches with at least one set of contacts in case of said

induction motor of single-phase type, or at least two sets contacts in case of said induction motor of three-phase type, opens the low-impedance path for the low-power alternating current, generated by the mechanical rotation of the rotor of said induction motor in the absence of its driving electrical power, to the source of said electrical power and various transforming and/or driving elements thereof; the second set of electromagnetically operated switches with at least one set of contacts which closes in the event of said first set of electromagnetically operated switches having opened due to an electrical command to it or due to an electrical power outage.
allows for the routing of aforementioned low-power alternating current ganerated by said

induction motor in aforesaid condition, as a signal to any process-control device or equipment regardless of said signal's manifestation in the form of any alarm or display, whereas for complete electrical isolation between said alternating current signal produced by said induction motor in said condition and the source of said electrical power together with various transforming and/or driving elements thereof, the numbers of sets of contacts in aforesaid two numbers of sets of electromagnetically operated switches are incremented by one apiece.